

TECHNICAL REPORT ARBRL-TR-02238

ROLE OF THE INSULATING LAYER FROM  
 $\text{TiO}_2$ -WAX LINER IN REDUCING  
GUN TUBE WEAR

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Timothy L. Brosseau

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April 1980



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## 20. ABSTRACT: (Cont'd)

of flaps and an insulating deposit formed with successive firings of  $TiO_2$ -wax rounds. To test the hypothesis the insulating residue contributes to erosion-protection and to establish credibility of the heat transfer to design additives, a 1200-round firing test was conducted in which 600 APDS and 600 HEP rounds were fired alternately. Based on wear per round established for APDS and HEP rounds, one would have expected 0.19 mm of wear for the 1200 rounds. Instead, the 1200-round test produced 1.9 mm of wear establishing the importance of the insulating residue.

It was also observed the secondary wear increased for the alternate APDS-HEP round test. This confirms an earlier hypothesis that the secondary wear arises because the additive is not effective down bore.

The total wear of 1.9 mm was twice as much as predicted from a correlation between heat input and wear. It is postulated that the APDS round is more erosive when it is preceded by a low-velocity HEP round than by another APDS round. The extra erosivity of the APDS round is attributed to a thicker oxide layer left on the barrel by the HEP round.

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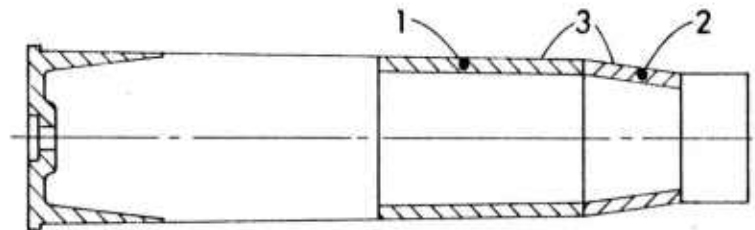
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## I. INTRODUCTION

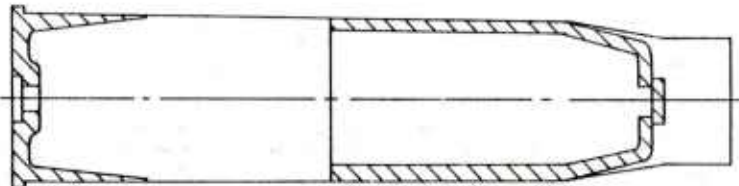
The only advance in barrel wear reduction since the Second World War work on erosion<sup>1</sup> has been the wear-reducing liner. The original wear-reducing liner was invented in Canada<sup>2</sup> and is composed of a high-density polyurethane foam glued to the wall of a cartridge case. Soon after the US adopted the polyurethane foam in high-velocity tank guns, Swedish inventors devised a liner made from a 45/55 percent by weight blend of  $\text{TiO}_2$  and paraffin wax<sup>3</sup>. The Swedish also modified the configuration of the liner by cutting flaps that were folded over the propellant at the projectile base. Figure 1 depicts each liner in the 105 mm M115B1 cartridge case to illustrate how the liners are loaded and to show the flaps the Swedish inventors devised.

### STANDARD POLYURETHANE LINER



- 1. LARGE POLYURETHANE (.087 kg)
- 2. SMALL POLYURETHANE (.027 kg)
- 3. GLUED

### STANDARD $\text{TiO}_2$ /WAX LINER



- 1.  $\text{TiO}_2$ /WAX WITH FLAPS (.141 kg)

Figure 1. Configuration of Wear-Reducing Additives

<sup>1</sup>"Hypervelocity Guns and the Control of Gun Erosion", Summary Technical Report of Division 1, NDRC, Volume I, Washington, DC, 1946.

<sup>2</sup>L. A. Dickinson and D. E. McLennan, "Improvement of the Firing Accuracy and Cost Effectiveness of Guns Through the Use of Urethane Foams", *J. Cellular Plastics*, 1968, 184 (1968).

<sup>3</sup>S. Y. Ek and D. E. Jacobsen, "Engineering Study of Barrel Wear-Reducing Additives", Wegematic Corporation Report, Part A, May 1962.

The relative performance of the two additives is shown in Figures 2 and 3. Polyurethane foam increased the wear life from 100 to 400 rounds<sup>4</sup>; the Swedish additive yielded a wear life of 10,000 rounds<sup>5</sup>. In addition, the Swedish additive provided better downbore protection, especially at the region of secondary wear seen in Figure 3 with polyurethane foam.

The surprising difference between the polyurethane foam liner and the Swedish additive prompted work to discover why the Swedish additive was so effective. Two differences were evident, the flaps and the metal oxide,  $TiO_2$ , which might form an insulating residue. This speculation arose from the APG tests with Swedish additive in which a residue composed mainly of  $TiO_2$  was removed from the M68 cannon and analyzed. Table I compares Swedish additive and the residue.

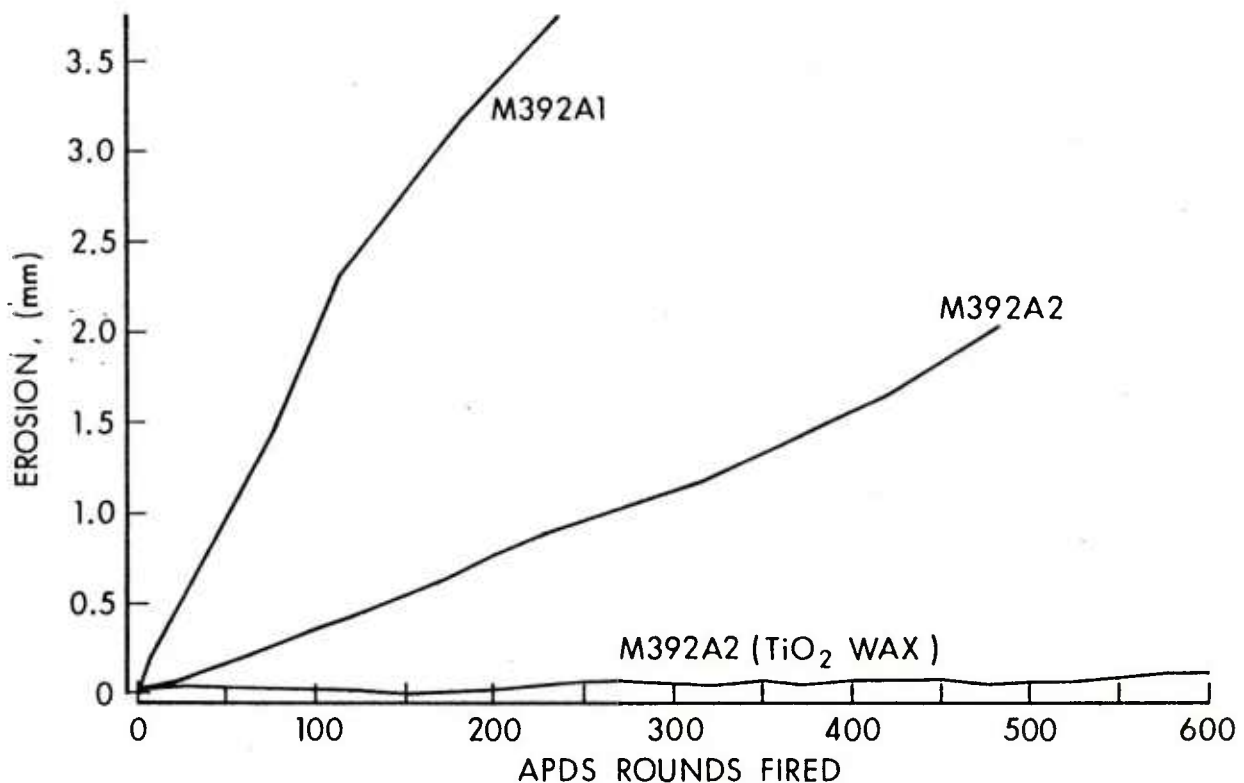


Figure 2. Erosion vs Rounds Fired for APDS Rounds

<sup>4</sup>R. Wolff, "Reduction of Gun Erosion - Part I. Laminar Coolant", Picatinny Arsenal Technical Report No. 3069, May 1963.

<sup>5</sup>R. O. Wolff, "Reduction of Gun Erosion Part II. Barrel Wear-Reducing Additive", Picatinny Arsenal Technical Report No. 3096, August 1963.



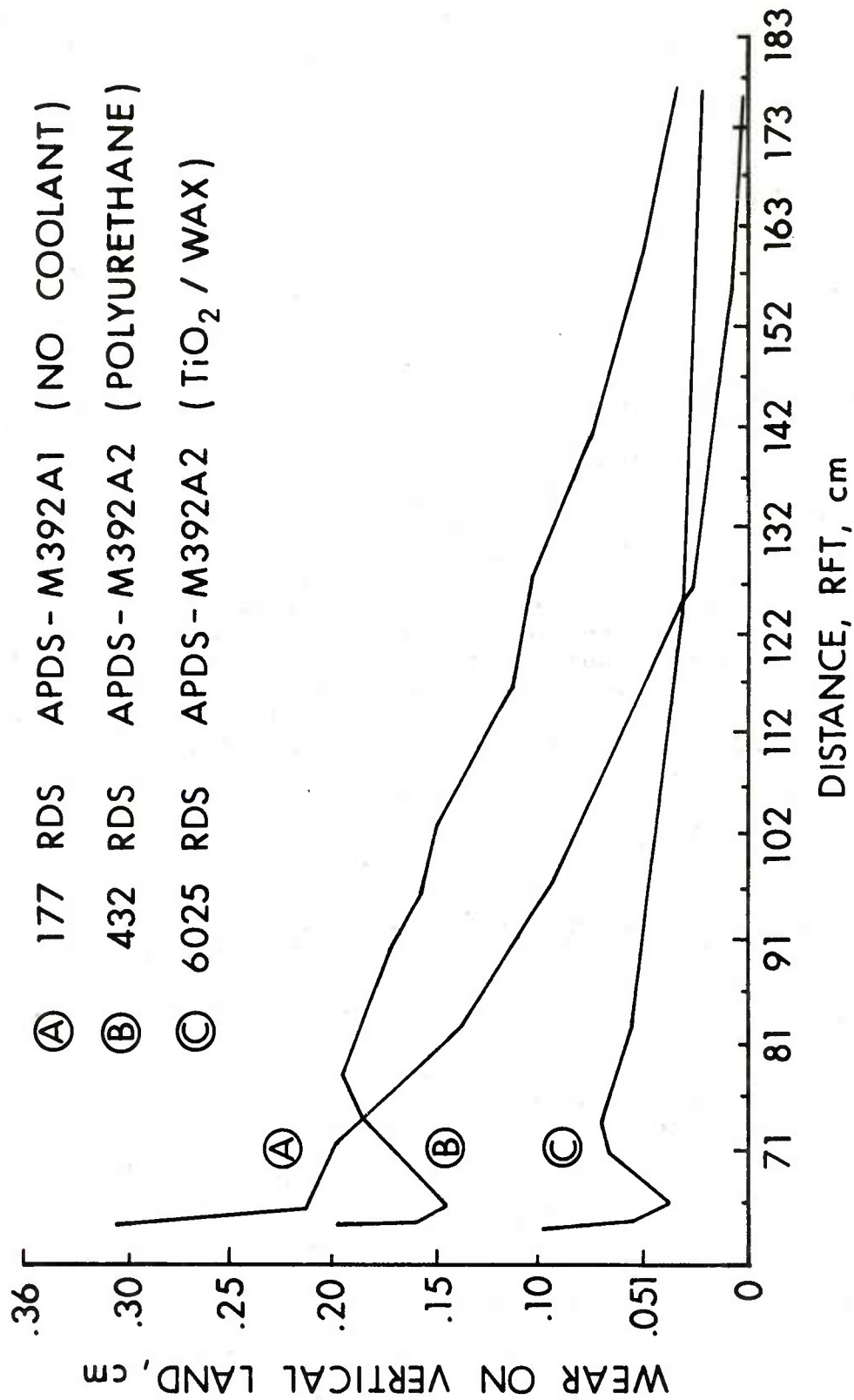


Figure 3. Wear Profile for M68 Tank Cannon Firing APDS Rounds

Table I. Composition of Swedish Additive and Bore Residue  
Recovered from Gun Firing Swedish Additive

<u>Swedish Additive, percent by weight</u>		<u>Residue, percent by weight</u>	
TiO <sub>2</sub>	46.0	TiO <sub>2</sub>	77.4
Wax	53.5	Wax	7.1
Dacron Staple	0.5	Silica	2.6
Stearyl Alcohol (1.0 maximum)		Inorganic Residue	7.7
Cloth: Viscose Rayon		Organic Residue	5.2

Change in heat input to the barrel was the technique applied to discern factors influencing the efficiency of the additives. Brosseau and Ward noted in the 37 mm gun<sup>6</sup> that the flaps enhanced the efficiency of the polyurethane foam and the TiO<sub>2</sub>-wax liner. When both liners were placed in the same configuration, heat input was equivalent. To separate any influence of bore residue, a "clean-out" round, i.e., a round with no additive, was fired after each round loaded with TiO<sub>2</sub>-wax. Calspan investigators<sup>7</sup> showed an insulating deposit was forming in the eight-inch M201 cannon when successive shots were fired with TiO<sub>2</sub>-wax additive. Brosseau and Ward<sup>8,9</sup> extended this to the 105 mm tank cannon. They showed that the flaps enhanced heat input reduction for the polyurethane foam and the TiO<sub>2</sub>-wax liner; they also fired TiO<sub>2</sub>-wax rounds successively until a minimum heat input was reached. The results are summarized in Table II. Figure 4 plots heat input vs wear which suggests the insulating residue is the principal factor contributing to the 10,000-round wear life for Swedish additive.

<sup>6</sup>T. L. Brosseau and J. R. Ward, "Reduction of Heat Transfer to Gun Barrels by Wear-Reducing Additives", BRL Memorandum Report No. 2464, March 1975. (AD#B003850L)

<sup>7</sup>F.A. Vassallo, "Heating and Erosion Techniques Applied to the Eight-Inch Howitzer", 12th JANNAF Combustion Meeting, Volume I, CPIA Publication 273, December 1975.

<sup>8</sup>T. L. Brosseau and J. R. Ward, "Reduction of Heat Transfer in the 105 mm Tank Gun by Wear-Reducing Additives", BRL Memorandum Report No. 2698, November 1976. (AD#B015308L)

<sup>9</sup>T. L. Brosseau and J. R. Ward, "Measurement of Heat Input into the 105 mm M68 Tank Cannon Firing Rounds Equipped with Wear-Reducing Additives", BRL Technical Report 2056, April 1978. (AD#A056368)

Parallel to the conduct of the heat input experiments, Army attention focused on the cause of the secondary wear. The accuracy of the armor piercing, discarding sabot round was affected adversely by the secondary wear with the result being the condemnation limit was dropped for the M68 tank cannon from 1.9 mm to 1.4 mm wear. Ward deduced that the secondary wear was caused by the reduced efficiency of the

Table II. Correlation Between Heat Transfer and Erosion in the 105 mm Tank Gun Firing the M392 Projectile

<u>Additive</u>	<u>Heat Input, J/mm<sup>*</sup></u>	<u>Erosion, <math>\mu\text{m}/\text{round}</math></u>	<u>Reference</u>
None	449	18	4
Polyurethane	416	4.1	4
TiO <sub>2</sub> -wax (flaps)- single-shot	381	--	--
TiO <sub>2</sub> -wax (flaps) repetitive fire	348	0.18	5

*\*Heat input measurements described in reference 9.*

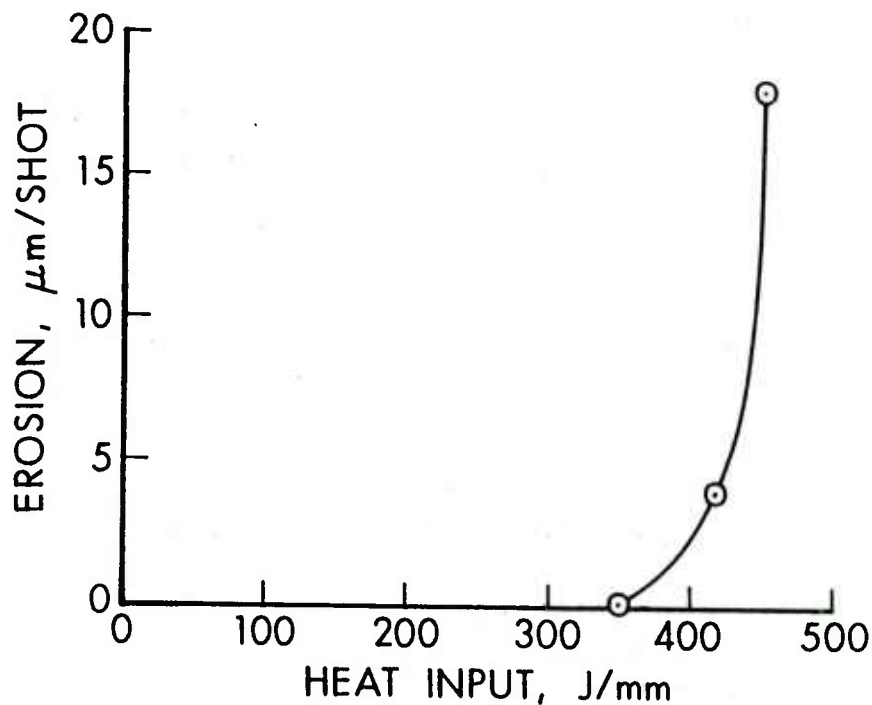


Figure 4. Heat Input vs Erosion for APDS Rounds

additive downbore<sup>10</sup>. Figure 5 compares the wear per round in the M68 cannon firing rounds without additive and polyurethane foam. The polyurethane foam is most effective at the commencement of rifling, but the efficiency drops downbore leading to the secondary wear peak. Figure 6 plots percent wear reduction vs distance to illustrate this point. The secondary wear is present with the TiO<sub>2</sub>-wax liner, but it is not a concern because the wear rate downbore is so slow as evidenced by Figure 3 that the 1,000 EFC rounds the M68 can fire before condemned for fatigue is reached long before the secondary wear poses a problem. Brosseau and Ward showed successive firing of TiO<sub>2</sub>-wax rounds reduced heat input downbore as well<sup>8</sup>. Hence, the secondary wear should be much worse in the M68 tank cannon firing TiO<sub>2</sub>-wax rounds if the residue does not form. Since the TiO<sub>2</sub>-wax round with flaps is still better than polyurethane foam, the secondary wear for TiO<sub>2</sub>-wax, no insulating residue, should be less than polyurethane foam, but worse than repeated firings with TiO<sub>2</sub>-wax.

The foregoing discussion has shown that if one could measure the erosivity of TiO<sub>2</sub>-wax without the insulating layer, one could test the hypotheses derived from heat input measurements, namely

- a. the wear predicted based on the heat transfer correlation will be 0.8  $\mu\text{m}/\text{round}$  and,
- b. the secondary wear will be more severe when the insulating residue doesn't form.

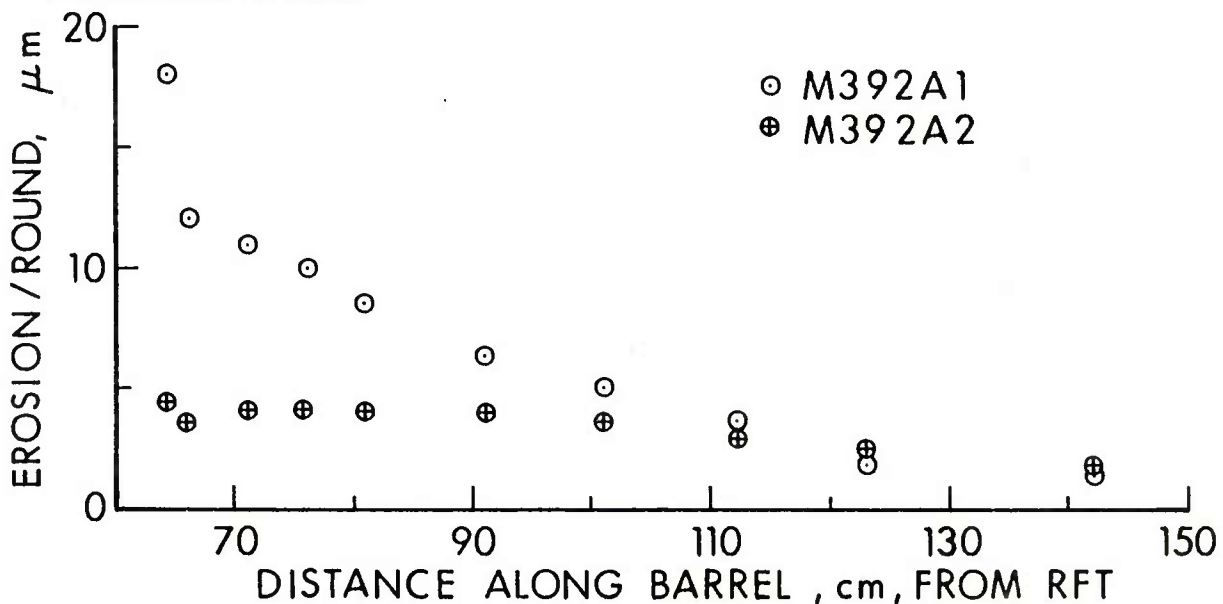


Figure 5. Wear Profile for APDS Without Additive and With Polyurethane Foam

<sup>10</sup>J. R. Ward, "Proposed Mechanism for Secondary Wear in the M68 Tank Cannon", BRL Memorandum Report No. 2557, November 1975. (AD#B008040L)

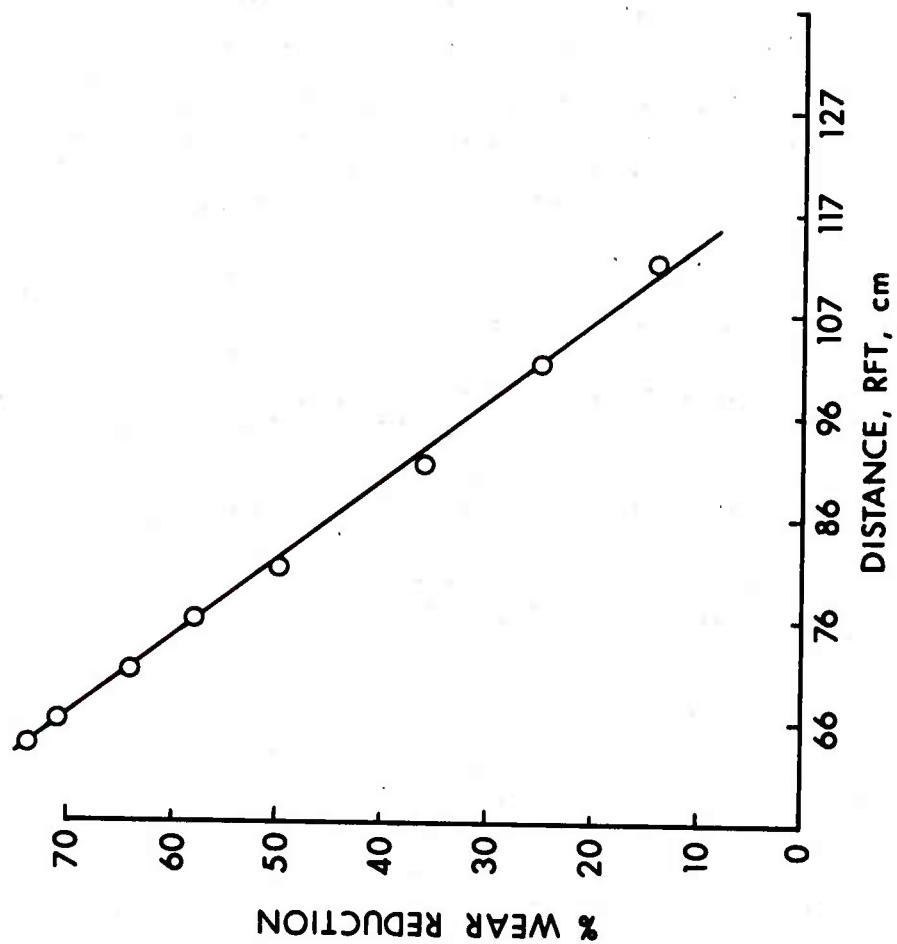


Figure 6. Percent Reduction in Wear Rate vs Distance from RFT

To measure the erosion without the residue, one need only continue repeating the sequence  $\text{TiO}_2$ -wax APDS round followed by a HEP round until measurable wear takes place. This report summarizes the results of such a test.

## II. EXPERIMENTAL

The test was done with standard 105 mm M392A2 projectiles and M467 target-practice projectiles as the clean-out rounds. The firings were performed under the auspices of Clyde Musick of the Materiel Testing Directorate (MTD), Aberdeen Proving Ground. The MTD report<sup>11</sup> covers ammunition lots used, firing schedule, and muzzle velocity and chamber pressure taken at the start of the test for each round.

The M68 cannon had fired previously twenty rounds during sabot-development testing. An in-bore malfunction damaged lands downbore during the sabot tests; the damaged region (3.886 to 5.105 mm RFT) was well past the region where the augmented bore erosion was postulated to occur.

## III. RESULTS AND DISCUSSION

The individual stargauge reports are collected in the Appendix. Table III summarizes vertical land wear at 641.4 mm RFT (25.25 inches).

Table III. Vertical Land Wear at 641.4 mm RFT vs Rounds Fired

<u>Tube Rd No.</u>	<u>Test Rd No.</u>	<u>Diameter Wear, mm</u>	<u>Wear, mm</u>
20	0	0.13	0
120	100	0.20	0.07
320	300	0.46	0.33
380	360	0.58	0.45
540	520	0.86	0.73
620	600	0.84	0.71
720	700	1.02	0.89
820	800	1.04	0.91
920	900	1.17	1.04
1220	1200	1.37	1.24

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<sup>11</sup>C. Musick, MTD Report in preparation.



Since six hundred HEP rounds should produce only 0.08 mm (3 mils)<sup>12</sup> wear, the preponderance of wear in the test is due to the APDS round without the benefit of the insulating residue. Shown in Figure 7 are curves comparing the erosion caused by the APDS round minus the insulating residue, the APDS round with no additive (M392A1), the APDS round with polyurethane foam (M392A2), and the APDS round with TiO<sub>2</sub> wax. As predicted from the heat transfer measurements, the round with polyurethane foam still produces more wear than the APDS round with TiO<sub>2</sub>-wax flaps without insulating residue. A corollary to this observation is that placing flaps on polyurethane foam will decrease erosion, but the polyurethane foam will never provide the protection afforded by repeated firings of rounds with TiO<sub>2</sub>-wax additive.

The downbore wear produced by the 1200 APDS and HEP rounds is illustrated in Figures 8 and 9 along with wear profiles for the APDS round without additive and with the two standard additives. As anticipated, the secondary wear is greater when the insulating residue is removed providing credence to the earlier hypothesis<sup>10</sup> that secondary wear is related to the relative effectiveness of the wear-reducing additive. Again, the secondary wear for the combination APDS-HEP rounds is still less than the secondary wear for the APDS round with polyurethane foam.

Although the wear for the APDS-HEP round is still less than the APDS round with polyurethane foam, the wear for the APDS round inferred from heat transfer vs wear in Figure 4 would be 0.9  $\mu\text{m}/\text{round}$ . On the basis that the wear from the APDS and HEP round can be decoupled, the APDS wear is 1.16 mm in 600 rounds after subtracting the 0.08 mm wear for 600 HEP rounds. This is a wear of 1.9  $\mu\text{m}/\text{round}$ , considerably higher than the 0.9  $\mu\text{m}/\text{round}$  from the heat transfer correlation and well outside the error for the other three points. This can be further illustrated from a semi-log plot of wear vs heat input in Figure 10 where one sees the 1.9  $\mu\text{m}/\text{round}$  for the 381 J/mm heat input of the APDS (TiO<sub>2</sub>-wax) with no insulating residue falls well outside the correlation for the other three points.

An alternate explanation is that the wear for the APDS and HEP rounds cannot be decoupled. Instead, the wear for the 1200 alternating APDS-HEP rounds is more severe than the total expected from 600 HEP and 600 APDS eliminating the insulating residue. Some evidence for such synergism is found in experiments by Niiler and co-workers on the oxygen concentration profile on steel exposed to combustion gases<sup>13,14</sup>.

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<sup>12</sup>L. R. Neally, "Development and Engineering Tests of Cartridge, 105 mm, M393E1, HEP-T and TP-T", DPS Report No. 463, June 1962.

<sup>13</sup>A. Niiler, J. E. Youngblood, S. E. Caldwell, and T. J. Rock, "An Accelerator Technique for the Study of Ballistic Surfaces", BRL Report No. 1815, August 1975. (AD#A016899)

<sup>14</sup>A. Niiler and R. Birkmire, "Composition Changes in Gun Steel Surfaces Due to Erosive Propellant Burn", Proceedings of the Tri-Service Gun Tube Wear and Erosion Symposium, Dover, NJ, March 1977.

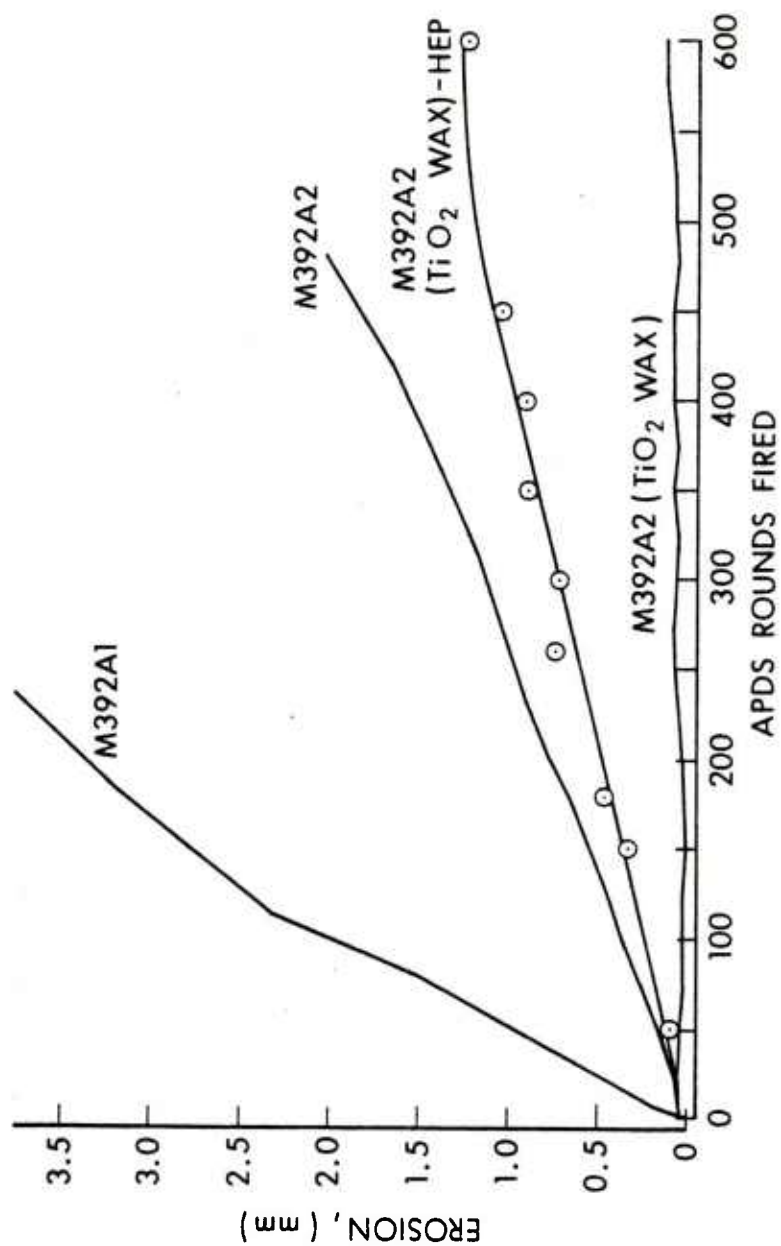


Figure 7. Erosion vs Rounds Fired for APDS Rounds Including APDS-HEP Series



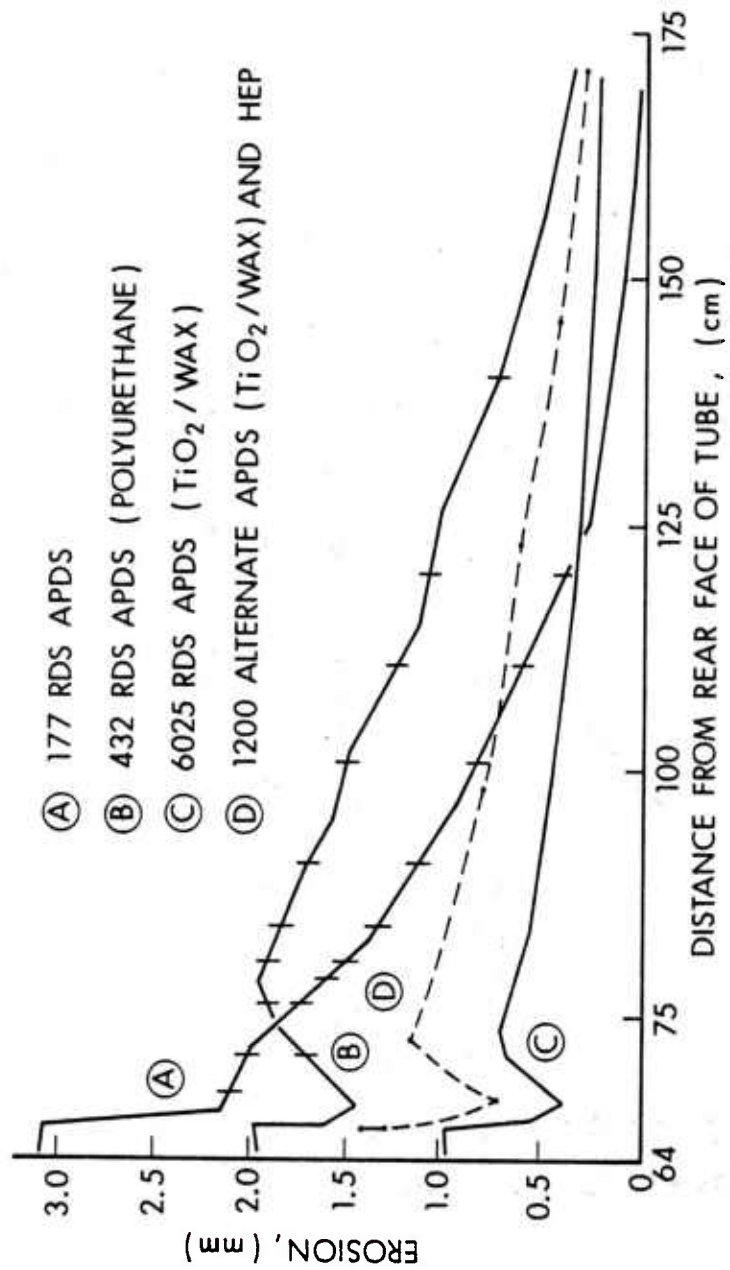


Figure 8. Erosion vs Distance Measured from RFT for APDS Rounds with Additives

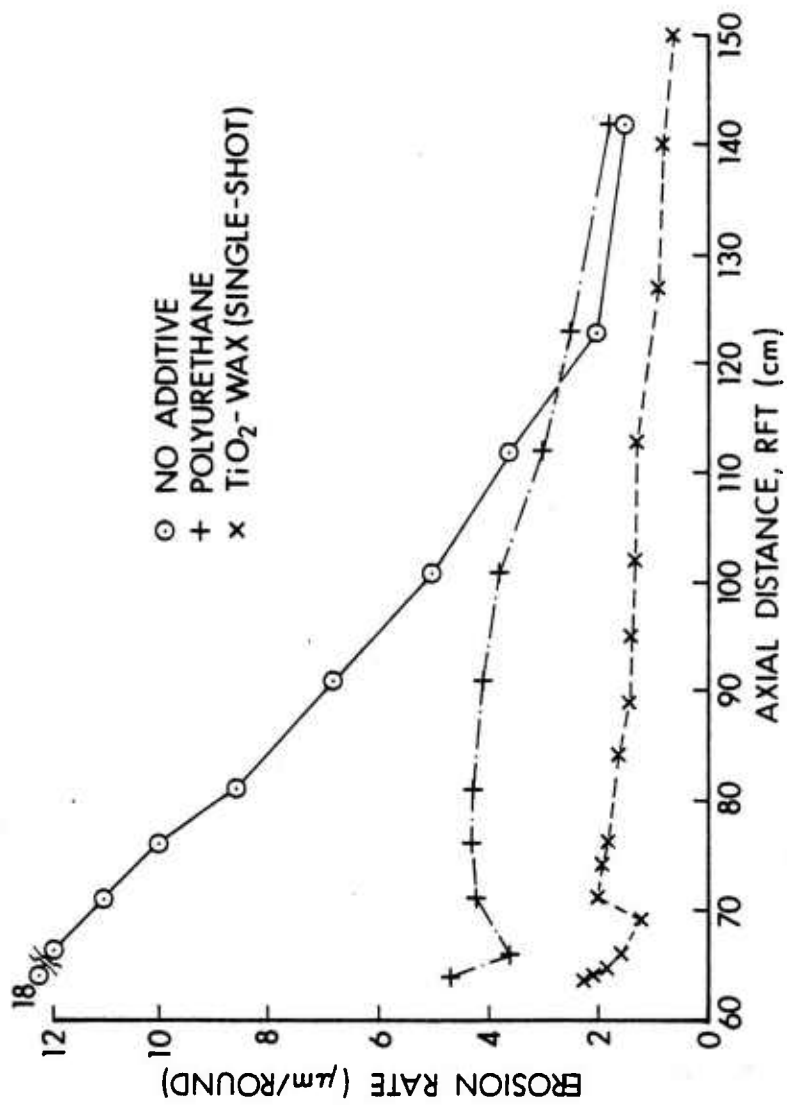


Figure 9. Wear Profile for the M68 Tank Cannon for APDS Rounds with Secondary Wear

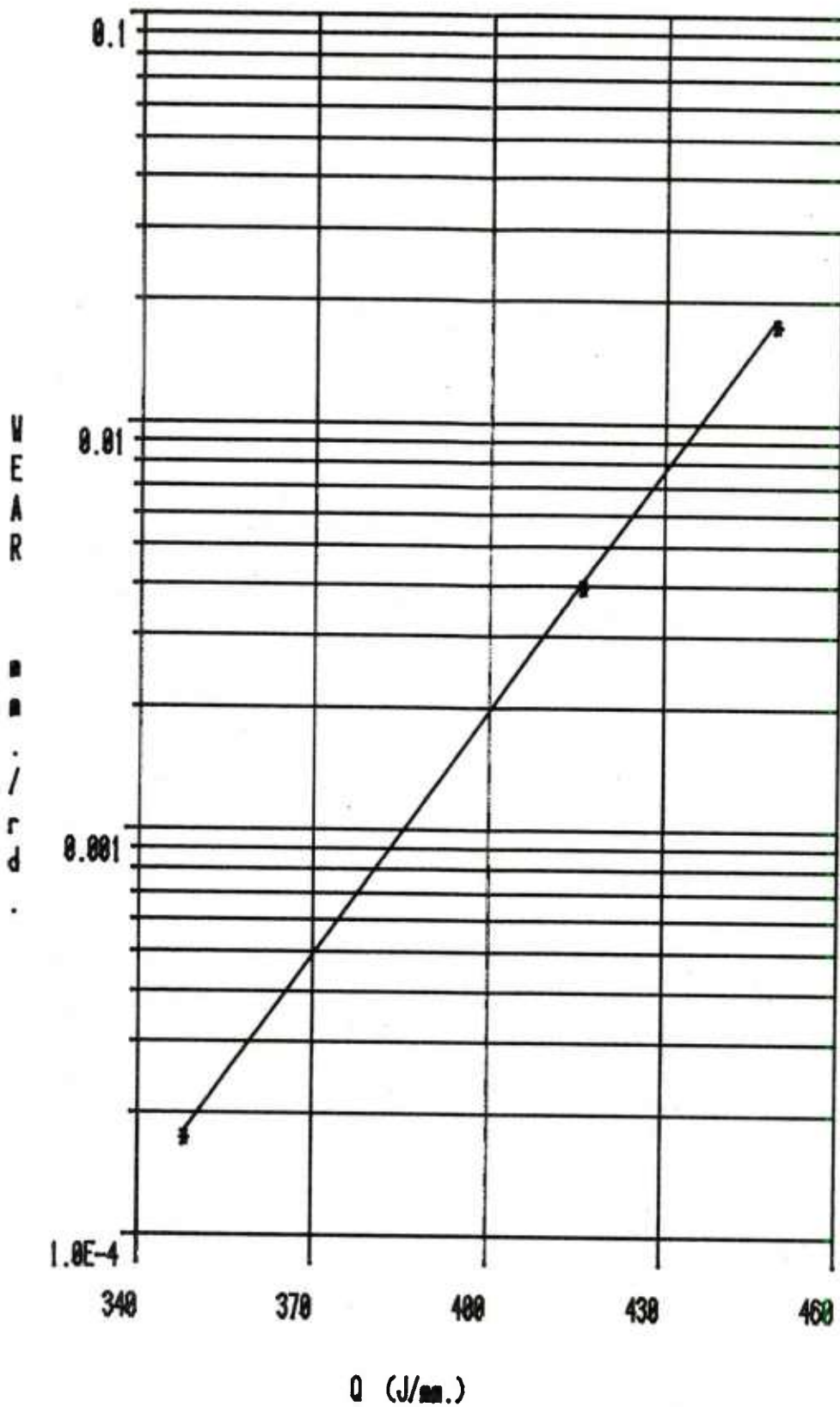


Figure 10. Correlation Between Wear and Heat Input for APDS Rounds with Additives

Table IV summarizes results for propellants with three flame temperatures. One sees the propellant with the higher flame temperature and concomitant higher wear also has the lower oxygen content left on the steel nozzle. This suggests the oxide layer is not as resistant to the hot, flowing gases as steel, since the M2 propellant gases should be as oxidizing as the gases from M1 propellant. Firing a HEP round with M1 propellant may condition the barrel so the next round with M30 propellant will produce more wear than when only rounds with M30 are fired. To demonstrate this conclusively, one need fire rounds without the complication from the insulating residue. Such a combination might be alternate firings of APDS rounds with polyurethane foam and HEP rounds.

Table IV. Oxygen Concentration Profiles on Steel Exposed to Propellants with Different Flame Temperatures

<u>Propellant</u>	<u>Flame Temperature, K</u>	<u>Oxygen, atoms/cm<sup>2</sup>, x 10<sup>-16</sup></u>
M2	3375	9
M30	2994	17
M1	2480	34

#### IV. CONCLUSIONS

1. The superiority of the TiO<sub>2</sub>-wax liner vs the polyurethane liner in the M392A2 APDS projectile arises from the deposition of an insulating residue on the bore surface as well as the presence of flaps on the TiO<sub>2</sub>-wax liner.
2. The heat transferred to the gun barrel can be used to infer the relative efficiency of a wear-reducing additive.
3. Secondary wear with the M392A2 projectile increased dramatically when the insulating layer was not allowed to form. This suggests secondary wear arises from the relative efficiency of the wear-reducing additive at the commencement of rifling vs downbore protection.
4. The wear from an APDS round appears higher if the APDS round is preceded by a HEP round than by another APDS round.

## REFERENCES

1. "Hypervelocity Guns and the Control of Gun Erosion", Summary Technical Report of Division 1, NDRC, Volume I, Washington, DC, 1946.
2. L. A. Dickinson and D. E. McLennan, "Improvement of the Firing Accuracy and Cost Effectiveness of Guns Through the Use of Urethane Foams", J. Cellular Plastics, 1968, 184 (1968).
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5. R. O. Wolff, "Reduction of Gun Erosion - Part II. Barrel Wear-Reducing Additive", Picatinny Arsenal Technical Report No. 3096, August 1963.
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7. F. A. Vassallo, "Heating and Erosion Techniques Applied to the Eight-Inch Howitzer", 12th JANNAF Combustion Meeting, Volume 1, CPIA Publication 273, December 1975.
8. T. L. Brosseau and J. R. Ward, "Reduction of Heat Transfer in the 105 mm Tank Gun by Wear-Reducing Additives", BRL Memorandum Report No. 2698, November 1976. (AD#B015308L)
9. T. L. Brosseau and J. R. Ward, "Measurement of Heat Input into the 105 mm M68 Tank Cannon Firing Rounds Equipped with Wear-Reducing Additives", BRL Technical Report 2056, April 1978. (AD#A056368)
10. J. R. Ward, "Proposed Mechanism for Secondary Wear in the M68 Tank Cannon", BRL Memorandum Report No. 2557, November 1975. (AD#B008040L)
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13. A. Niiler, J. E. Youngblood, S. E. Caldwell, and T. J. Rock, "An Accelerator Technique for the Study of Ballistic Surfaces", BRL Report No. 1815, August 1975. (AD#A016899)
14. A. Niiler and R. Birkmire, "Composition Changes in Gun Steel Surfaces Due to Erosive Propellant Burn", Proceedings of the Tri-Service Gun Tube Wear and Erosion Symposium, Dover, NJ, March 1977.

APPENDIX  
STARGAUGE MEASUREMENTS

ENGINEERING MEASUREMENTS AND ANALYSIS DIVISION  
PHYSICAL TEST BRANCH REPORT  
NO. 77-L-63

STEAP-MT-G

Date of Test 26 Sep 77

Title Measurements of 105 MM, M68 Cannon Tube SN 24850 (Special)

TECOM Project Title Product Improvement Test Cartridge, 105 MM, M735

TECOM Project No. 1-MU-001-735-008 W. O. No. 445-92777-93

Conducted for Mr. Ruff, Artillery Ammo Br

Reference TM 9-1000-202-14, MP 750-1

OBJECT OF TEST:

To inspect and identify those conditions which may ballistically effect the cannon tube operation or personnel safety in accordance with TM 9-1000-202-14.

INTRODUCTION:

105 mm M68 cannon tube SN 24850 (Special) after firing 20 rounds was submitted for determination of its physical characteristics.

PROCEDURE:

1. Chamber, Bore and Rifling Diametrical Measurements:

a. The chamber and centering cylinder were diametrically measured using a vernier stargage equipped with a 120° spaced three point measuring head. The gage vernier was adjusted to coincide with a 5.000-inch (127.00 mm) ring gage for the area between .10 inches (2.50 mm) and 18.40 inches (467.36 mm) from rear face of tube (RFT) and a 4.400-inch (111.76 mm) ring gage for the area between 21.85 inches (554.99 mm) and 24.05 inches (610.87 mm) from RFT. The measurements were taken with the points in a 2-6-10 o'clock position and again with the points in a 4-8-12 o'clock position. The vernier stargage measurements added to the respective ring gage diameters were taken to be the actual diameters of the chamber.

b. The main bore was diametrically measured using a vernier star-gage equipped with a four point head having two measuring points spaced 180° apart. The gage vernier was first adjusted to coincide with a 4.134-inch (105.00 mm) ring gage for measurements across the bore and secondly to coincide with a 4.224-inch (107.29 mm) ring gage for measurements across the rifling between 25.10 inches (637.54 mm) and 210.25 inches (5340.35 mm) from RFT. The measuring points were locked into position, using a guide plate at the muzzle, in such a manner that by following the rifling twist to the commencement of rifling the measuring points were located in a 12-6 o'clock position for the measurements, in turn, across the vertical bore and



rifling. The measuring points were then rotated 90° from the vertical position at the muzzle and by following the same procedure as previously outlined the measuring points were located in a 3-9 o'clock position for the measurements, in turn, across the horizontal bore and rifling. The variations from the basic diameters were shown on the gage vernier in +.001-inch (.0254 mm) increments.

c. The bore diameter was measured in a vertical and horizontal plane at 25.25 inches (641.35 mm) from RFT using a 105-mm pullover vernier gage having a basic diameter of 4.134 inches (105.00 mm).

## 2. Detection of Defects:

The complete bore was visually inspected using a white light borescope to observe for heat checking, erosion, scoring, damage, cracks, and/or other defects.

## TEST RESULTS:

1. Chamber, centering cylinder and main bore .10 inch (2.50 mm) to 210.25 inches (5340.35 mm) from RFT.

a. The chamber, .10 inch (2.50 mm) to 18.40 inches (467.36 mm) from RFT and centering cylinder 21.85 inches (554.99 mm) to 24.05 inches (610.87 mm) from RFT, measurements are shown in Appendix I.

b. The main bore measurements 25.10 inches (637.54 mm) to 210.25 inches (5340.35 mm) from RFT are shown in Appendix I.

2. Pullover vernier gage measurements 25.25 inches (641.35 mm) from RFT.

a. The pullover vernier gage measurement 25.25 inches (641.35 mm) from RFT showed a bore diameter of 4.141 inches (105.18 mm) vertically and 4.140 inches (105.16 mm) horizontally.

b. The vertical measurement at 25.25 inches (641.35 mm) from RFT as compared to the 105 mm M68 wear pattern chart (life remaining) showed a remaining wear life of 93%.

## 3. White Light Borescope.

Complete borescope remarks are shown in Appendix I.

## CONCLUSIONS:

### 1. Stargage Measurements:

a. The chamber and centering cylinder measurements showed a normal diameter for a 105 mm M68 cannon tube.



b. The main bore measurements showed a normal wear pattern for a 105 mm M68 cannon tube between 25.10 inches (637.54 mm) and 60 inches (1524 mm) from RFT. The measurements of both the bore and rifling between 60 inches (1524 mm) and the muzzle showed enlargement indicating scoring and abrasive wear.

## 2. White Light Borescoping:

The tube contained damages to the rifling between 153 inches (3886.20 mm) and 201 inches (5105.40 mm) from RFT. These damages consist of rifling stripped and flattened. The damages in conjunction with the irregular scoring and abrasive wear would adversely affect the obturation of any type of projectile fired and thus adversely affect the ballistic operation of the tube and the safety of operating personnel. It is therefore declared "Hazardous" and stencilled in accordance with MP 750-1.

1 Incl

Appendix I - Chamber, Bore and Rifling Measurements Data and Borescope Remarks

SUBMITTED:



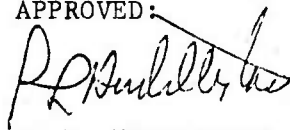
J. V. MCWILLIAMS, III  
Measurements Section

REVIEWED:



K. A. JONES  
Chief  
Measurements Section

APPROVED:



R. L. HUDDLESTON  
Chief  
Physical Test Branch

Table 1. 105 MM M68 Cannon Tube SN 24850 (Special) Chamber  
Diametrical Measurements after 20 Rounds

DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH						
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	ZERO	ORIGINAL 1			ADJUSTED 2		
					GAUGE READING	ACTUAL DIAMETER	DIFFERENCE	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.416	4.400	+017	4.417	+001	+017	4.417	+001
31.00	187.50	23.00	4.427		30	430	3	29	429	2
30.00	188.50	22.00	4.437		40	440	3	40	440	3
29.85	188.65	21.85	4.438		+042	4.442	+004	+041	4.441	+003
26.40	192.10	18.40	4.977	5.000	-020	4.980	+003	-021	4.979	+002
26.00	192.50	18.00	4.985		11	989	4	11	989	4
24.00	194.50	16.00	5.025		+028	5.028	3	+027	5.027	2
22.00	196.50	14.00	5.065		68	68	3	67	67	2
20.00	198.50	12.00	5.105		107	107	2	107	107	2
18.00	200.50	10.00	5.145		147	147	2	147	147	2
16.00	202.50	8.00	5.185		188	188	3	188	188	3
14.00	204.50	6.00	5.225		230	230	5	228	228	3
12.00	206.50	4.00	5.265		269	269	4	268	268	3
10.00	208.50	2.00	5.305		308	308	3	308	308	3
9.00	209.50	1.00	5.325		328	328	3	327	327	2
8.50	210.50	.50	5.335		338	338	3	337	337	2
8.25	210.25	.25	5.340		342	342	2	342	342	2
8.10	210.40	.10	5.343		+345	5.345	+002	+345	5.345	+002

Table 2. 105 MM M68 Cannon Tube SN 24850 (Special) Bore  
Diametrical Measurements after 20 Rounds

Distance (Inches) from			Diameter Indicated in 1/1000 of an inch			
Rear Face of Breech	Muzzle Face	Rear Face of Tube	4.13" Basic Diameter	4.22" Basic Diameter	4.13" Basic Diameter	4.22" Basic Diameter
			Vert.	Hor.	Vert.	Hor.
218.25	.25	210.25	+005	+005	+029	+024
217.00	1.50	209.00	+005	+005	24	21
215.00	3.50	207.00	+005	+005	23	19
213.00	5.50	205.00	+005	+005	22	18
208.00	10.50	200.00	+005	+005	23	18
203.00	15.50	195.00	+005	+005	21	20
198.00	20.50	190.00	+005	+005	24	21
193.00	25.50	185.00	+005	+005	22	20
188.00	30.50	180.00	+005	+005	23	21
183.00	35.50	175.00	+005	+005	24	21
178.00	40.50	170.00	+005	+005	21	21
173.00	45.50	165.00	+005	+005	21	20
168.00	50.50	160.00	+005	+005	24	20
163.00	55.50	155.00	+005	+005	24	20
158.00	60.50	150.00	+005	+005	25	17
153.00	65.50	145.00	+005	+005	24	20
148.00	70.50	140.00	+005	+005	17	19
143.00	75.50	135.00	+005	+005	17	19
138.00	80.50	130.00	+005	+005	18	19
133.00	85.50	125.00	+005	+005	17	19
128.00	90.50	120.00	+005	+005	16	19
123.00	95.50	115.00	+005	+005	14	19
118.00	100.50	110.00	+005	+005	14	19
113.00	105.50	105.00	+005	+005	12	19
108.00	110.50	100.00	+005	+005	10	19
103.00	115.50	95.00	+005	+005	10	19
98.00	120.50	90.00	+005	+005	10	19
93.00	125.50	85.00	+005	+005	10	19
88.00	130.50	80.00	+005	+005	10	19
83.00	135.50	75.00	+005	+005	10	19
78.00	140.50	70.00	+005	+005	10	19
73.00	145.50	65.00	+005	+005	10	19
68.00	150.50	60.00	+005	+005	10	19
63.00	155.50	55.00	+005	+005	10	19
58.00	160.50	50.00	+005	+005	10	19
53.00	165.50	45.00	+005	+005	10	19
48.00	170.50	40.00	+005	+005	10	19
45.25	173.25	37.25	+005	+005	10	19
43.00	175.50	35.00	+005	+005	10	19
41.25	177.25	33.25	+005	+005	10	19
38.00	180.50	30.00	+005	+005	10	19
37.00	181.50	29.00	+005	+005	10	19
36.00	182.50	28.00	+005	+005	10	19
35.00	183.50	27.00	+005	+005	10	19
34.00	184.50	26.00	+005	+005	10	19
33.50	185.00	25.50	+005	+005	10	19
33.25	185.25	25.25	+005	+005	10	19
33.10	185.10	25.10	+005	+005	10	19



Table 3. 105 MM M68 Cannon Tube SN 24850 (Special) Borescope  
Remarks after 20 Rounds

not measured. Borescoped: (Not Chrome Plated)
Light scratches, stains, carbon and other deposits thru-out chamber and main bore. Two piezo gage holes drilled in chamber. One at 14.37" from rear face of tube in the 10:00 o'clock area and one at 20.5" from (RFT) in the 2:30 o'clock area. Light erosion and scoring encircling both holes. Two piezo gage holes drilled in bore. One at 28" (RFT) in the 10:00 o'clock area and one at 38" (RFT) in the 2:30 o'clock area. Light heat checking on edges where holes are drilled thru the lands. Light heat checking encircling non-rifled portion of forcing cone and extending forward to 60" from (RFT). Any further heat checking obscured by carbon deposits. Very light erosion encircling forcing cone area. Edges of lands lightly rounded to 75" from (RFT). Moderate erosion and scoring encircling bore evacuator holes. Tube contains damage to 18 lands in the 11:00 o'clock area between 153" and 201" from (RFT). Damages consist of lands being stripped and flattened. Tube contains moderate scoring and abrasive wear on lands and in the grooves between 60" from (RFT) and the muzzle.

MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM (PT-IOP 750-1)

105 MM Tube, 1468		Main Bore - 21.91" to 210.50"				
Distance (Inches) from		Rear Face of Breech	Muzzle Face	Rear Face of Tube	4.131" Basic Diameter	4.224" Basic Diameter
					Vert.	Hor.
218.25	.25	210.25				
217.00	1.50	209.00				
215.00	3.50	207.00				
213.00	5.50	205.00				
208.00	10.50	200.00				
203.00	15.50	195.00				
198.00	20.50	190.00				
193.00	25.50	185.00				
188.00	30.50	180.00				
183.00	35.50	175.00				
178.00	40.50	170.00				
173.00	45.50	165.00				
168.00	50.50	160.00				
163.00	55.50	155.00				
158.00	60.50	150.00				
153.00	65.50	145.00				
148.00	70.50	140.00				
143.00	75.50	135.00				
138.00	80.50	130.00				
133.00	85.50	125.00				
128.00	90.50	120.00				
123.00	95.50	115.00				
118.00	100.50	110.00				
113.00	105.50	105.00				
108.00	110.50	100.00				
103.00	115.50	95.00				
98.00	120.50	90.00				
93.00	125.50	85.00				
88.00	130.50	80.00				
83.00	135.50	75.00				
78.00	140.50	70.00				
73.00	145.50	65.00				
68.00	150.50	60.00				
63.00	155.50	55.00				
58.00	160.50	50.00				
53.00	165.50	45.00				
48.00	170.50	40.00				
43.25	173.25	37.25				
43.00	175.50	35.00				
41.25	177.25	33.25				
38.00	180.50	30.00	+0.003	+0.004	+0.004	+0.005
37.00	181.50	29.00	3	4	4	6
36.00	182.50	28.00	2	4	5	6
35.00	183.50	27.00	2	3	5	6
34.00	184.50	26.00	4	3	6	7
33.50	185.00	25.50	6	5	6	7
33.25	185.25	25.25	8	7	5	7
33.10	185.10	25.10	+0.010	+0.008	+0.005	+0.006
Pullover Meas.			Vert.	Hor.		
25.25"					92% Estimated Remaining Accuracy	
* TUBE DECLARED "HAZARDOUS" DUE TO DAMAGE IN BORE					Life *	

105 MM Tube M68				CHAMBER 0.00" to 21.91"						
DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH						
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.15	24.05	4.416	4.004"						
31.00	187.50	23.00	4.427							
30.00	188.50	22.00	4.437							
29.85	188.65	21.85	4.438							
26.40	192.10	18.40	4.977	5.000"						
26.00	192.50	18.00	4.985							
24.00	194.50	16.00	5.025							
22.00	196.50	14.00	5.065							
20.00	198.50	12.00	5.105							
18.00	200.50	10.00	5.145							
16.00	202.50	8.00	5.185							
14.00	204.50	6.00	5.225							
12.00	206.50	4.00	5.265							
10.00	208.50	2.00	5.305							
9.00	209.50	1.00	5.325							
8.50	210.50	.50	5.335							
8.25	210.25	.25	5.340							
8.10	210.40	.10	5.343							

SPECIAL MEASUREMENTS					
	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	218.50"	—	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	210.50"	—	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	8.00"	—	NUMBER OF LANDS AND GROOVES	28	28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

Borescoped: (Not Chrome Plated)

No appreciable changes noted at this time. Damages mentioned in borescope remarks dated 26 Sept. 77 remain essentially the same with the exception of sharp edges being smoothed over by additional rounds.

STAMPED	STARGAUGED AND INSPECTED BY MOODY	REVIEWED BY
ROOMMAN GILLEY	TIME	COMPILER
RECORDER	PLACE 525	GRAPHED BY

105 MM TUBE 24850 M68  
11 SEP 78 AF 120 Rds.

WTF ARS.

FOR: W/2. MUSIC  
W.O. 445-36852-87



(PT-IOP 750-1

Page 102		105 MM Tube, M68							
		Main Bore - 21.91" to 210.50"							
		Case Head Indicated in 1/1000 of an inch							
		LANDS GROOVES							
		Basic Diameter							
		Vert. Hor. Vert. Hor.							
		Rear Face of Borech	Muzzle Face	Rear Face of Tube	+ .006	+ .006	+ .030	+ .025	
		218.25	.25	210.25					
		217.00	1.50	209.00					
		215.00	3.50	207.00					
		213.00	5.50	205.00					
		208.00	10.50	200.00					
		203.00	15.50	195.00					
		198.00	20.50	190.00					
		193.00	25.50	185.00					
		188.00	30.50	180.00					
		183.00	35.50	175.00					
		178.00	40.50	170.00					
		173.00	45.50	165.00					
		168.00	50.50	160.00					
		163.00	55.50	155.00					
		158.00	60.50	150.00					
		153.00	65.50	145.00					
		148.00	70.50	140.00					
		143.00	75.50	135.00					
		138.00	80.50	130.00					
		133.00	85.50	125.00					
		128.00	90.50	120.00					
		123.00	95.50	115.00					
		118.00	100.50	110.00					
		113.00	105.50	105.00					
		108.00	110.50	100.00					
		103.00	115.50	95.00					
		98.00	120.50	90.00					
		93.00	125.50	85.00					
		88.00	130.50	80.00					
		83.00	135.50	75.00					
		78.00	140.50	70.00					
		73.00	145.50	65.00					
		68.00	150.50	60.00					
		63.00	155.50	55.00					
		58.00	160.50	50.00					
		53.00	165.50	45.00					
		48.00	170.50	40.00					
		45.25	173.25	37.25					
		43.00	175.50	35.00					
		41.25	177.25	33.25					
		38.00	180.50	30.00					
		37.00	181.50	29.00					
		36.00	182.50	28.00					
		35.00	183.50	27.00					
		34.00	184.50	26.00					
		33.50	185.00	25.50					
		33.25	185.25	25.25					
		33.10	185.10	25.10	+ .02	+ .020	+ .007	+ .007	
105 FM Tube	DATE OF GAUGING 31 July 78	Pullover Meas. 25.25"	Vert. 4.152"	Hor. 4.151"	78% Estimated remaining accuracy life. (W&AR)				





Size	Number	Model	Manufacturer
105mm Tube	24850	M68	WTU. APS.
Date of Gaging	Firing Status (Check one)	Number of Rounds	Proof Officer M.L. MUSICK
31 July 78	Before <input type="checkbox"/> After <input checked="" type="checkbox"/>	320	W.O. 445-36852-87
INSPECTION REMARKS			
(PT-IOP 750-1)			
Borescoped: (Not Chrome Plated)			
<p>Light scratches, stains, carbon and other deposits thru-out chamber and main bore. Two piezo gaze holes drilled in chamber. One at 14.37" from rear face of tube (RFT) in the 10:00 o'clock area and one at 20.5" from (RFT) in the 2:30 o'clock area. Light erosion and scoring encircling both holes. Two piezo gaze holes drilled in bore. One at 28" from RFT in the 10:00 o'clock area and one at 38" from (RFT) in the 2:30 o'clock area. Moderate to light heat checking, erosion and scoring encircling piezo gaze holes in bore, more pronounced on forward edge. Moderate to light heat checking encircling non-rifled portion of forcing cone and extending forward to 75" in the grooves and to 105" on the lands from (RFT). Any further heat checking obscured by carbon deposits. Moderate to light erosion with light longitudinal scoring encircling forcing cone and extending forward to 55" from (RFT). Edges of lands rounded thru-out eroded area with driving edge rounded as far forward as 100" from (RFT). Moderate to heavy erosion and scoring encircling bore evacuator holes, more pronounced on forward edges. Tube contains damage to 18 lands in the 11:00 o'clock area between 153" and 201" from (RFT). Damages consist of lands being stripped and flattened. Tube contains moderate scoring and abrasive wear on lands and in the grooves between 60" from (RFT) and the muzzle. Light coppering in bore between origin of rifling and 45" from (RFT).</p> <p>No photographs or impressions taken at this time.</p> <p>Tube declared "HAZARDOUS" due to damages in bore. Stencil and handle in accordance with M.P. 750-1.</p>			

NUMBER		MODEL		MANUFACTURER		CASTING NUMBER	
24850		M68		W.T. ARS.			
FIRING STATUS (Check One)		NUMBER OF ROUNDS		PROOF OFFICER		V.O.	
BEFORE		380		MR MUSICIE		445-36852-87	
AFTER							
DATE OF GAUGING							
Z AUG 78							
105 MM Tube							
105 MM Can							
Distance (Inches) From		Main Body - 21.91" to 210.50"		Give Head, Indicated in 1/16" or an inch		LANDS GROOVES	
Rear Face of Bore	Muzzle Face	Rear Face of Tube	Basic Diameter	Basic Diameter	Basic Diameter	Basic Diameter	
			Vert.	Hor.	Vert.	Hor.	
218.25	.25	210.25					
217.00	1.50	209.00					
215.00	3.50	207.00					
213.00	5.50	205.00					
208.00	10.50	200.00					
203.00	15.50	195.00					
198.00	20.50	190.00					
193.00	25.50	185.00					
188.00	30.50	180.00					
183.00	35.50	175.00					
178.00	40.50	170.00					
173.00	45.50	165.00					
168.00	50.50	160.00					
163.00	55.50	155.00					
158.00	60.50	150.00					
153.00	65.50	145.00					
148.00	70.50	140.00					
143.00	75.50	135.00					
138.00	80.50	130.00					
133.00	85.50	125.00					
128.00	90.50	120.00					
123.00	95.50	115.00					
118.00	100.50	110.00					
113.00	105.50	105.00					
108.00	110.50	100.00					
103.00	115.50	95.00					
98.00	120.50	90.00					
93.00	125.50	85.00					
88.00	130.50	80.00					
83.00	135.50	75.00					
78.00	140.50	70.00					
73.00	145.50	65.00					
68.00	150.50	60.00					
63.00	155.50	55.00					
58.00	160.50	50.00					
53.00	165.50	45.00					
48.00	170.50	40.00					
43.25	173.25	37.25					
41.00	175.50	35.00					
41.25	177.25	33.25					
38.00	180.50	30.00	+ .014	+ .012	+ .007	+ .008	
37.00	181.50	29.00	13	15	8	8	
36.00	182.50	28.00	13	15	9	9	
35.00	183.50	27.00	9	10	10	12	
34.00	184.50	26.00	13	12	9	12	
33.50	185.00	25.50	17	17	9	10	
33.25	185.25	25.25	23	20	9	10	
33.10	185.10	25.10	+ .027	+ .025	+ .010	+ .010	
Pullover Meas.	Vert.	Hor.					
25.25"	4.158	4.157					



105 MM Tube M68				CHAMBER 0.00" to 24.94"		
DISTANCE (Inches) FROM				DICATION IN 1/1000 OF AN INCH		
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	GAUGE MEASUREMENTS	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.416	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
31.00	187.50	23.00	4.427			
30.00	188.50	22.00	4.437			
29.85	188.65	21.85	4.438			
26.40	192.10	18.40	4.977			
26.00	192.50	18.00	4.985			
24.00	194.50	16.00	5.025			
22.00	196.50	14.00	5.065			
20.00	198.50	12.00	5.105			
18.00	200.50	10.00	5.145			
16.00	202.50	8.00	5.185			
14.00	204.50	6.00	5.225			
12.00	206.50	4.00	5.265			
10.00	208.50	2.00	5.305			
9.00	209.50	1.00	5.325			
8.50	210.50	.50	5.335			
8.25	210.25	.25	5.340			
8.10	210.40	.10	5.343			

105 M/M TUBE  
AF  
M68  
Rds.

SPECIAL MEASUREMENTS			
	BASIC	ACTUAL	
TOTAL LENGTH OF GUN	218.50"		ROTATION OF TUBE AT BREECH
TOTAL LENGTH OF TUBE	210.50"		MOVEMENT OF TUBE AT BREECH
DEPTH OF BREECH RECESS	8.00"		NUMBER OF LANDS AND GROOVES
			28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

BORESCOPED: NO APPRECIABLE CHANGE  
IN BORE OF TUBE SINCE LAST BORE-  
SCOPING DATED 31 JULY 78 AFTER  
FIRING 320 RDS.

STAMPED	STARGAUGED AND INSPECTED BY	REVIEWED BY
RODMAN	MOODY	COMPILATOR
RECORDER	PLACE	GRAPHED BY
GILLEY	Barr B	

MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM (PT-IOP 750-1)

105 MM Tube, M68		Main Bore - 21.91" to 210.50"				
Distance (Inches) from		Wave Head, indicated in 1/16" of an inch				
Rear Face of Breech	Muzzle Face	Rear Face of Tube	Basic Diameter Vert.	Basic Diameter Hor.	Basic Diameter Vert.	Basic Diameter Hor.
218.25	.25	210.25				
217.00	1.50	209.00				
215.00	3.50	207.00				
213.00	5.50	205.00				
208.00	10.50	200.00				
203.00	15.50	195.00				
198.00	20.50	190.00				
193.00	25.50	185.00				
188.00	30.50	180.00				
183.00	35.50	175.00				
178.00	40.50	170.00				
173.00	45.50	165.00				
168.00	50.50	160.00				
163.00	55.50	155.00				
158.00	60.50	150.00				
153.00	65.50	145.00				
148.00	70.50	140.00				
143.00	75.50	135.00				
138.00	80.50	130.00				
133.00	85.50	125.00				
128.00	90.50	120.00				
123.00	95.50	115.00				
118.00	100.50	110.00				
113.00	105.50	105.00				
108.00	110.50	100.00				
103.00	115.50	95.00				
98.00	120.50	90.00				
93.00	125.50	85.00				
88.00	130.50	80.00				
83.00	135.50	75.00				
78.00	140.50	70.00				
73.00	145.50	65.00				
68.00	150.50	60.00				
63.00	155.50	55.00				
58.00	160.50	50.00				
53.00	165.50	45.00				
48.00	170.50	40.00				
43.25	173.25	37.25				
43.00	175.50	35.00				
43.25	177.25	33.25				
38.00	180.50	30.00	+0.024	+0.020	+0.014	+0.014
37.00	181.50	29.00	25	26	14	15
36.00	182.50	28.00	22	23	13	15
35.00	183.50	27.00	17	16	20	18
34.00	184.50	26.00	22	21	17	19
33.50	185.00	25.50	26	26	15	15
33.25	185.25	25.25	34	32	15	15
33.10	185.10	25.10	+0.039	+0.038	+0.015	+0.015
Pullover Meas.		Vert.	Hor.	54% Estimated remaining accuracy life (WEAR)		
25.25"		4.169"	4.167"			
TUBE DECLARED HAZARDOUS DUE TO DAMAGE IN BORE						
TUBE EXTREMELY HOT AT TIME OF GAUGING						





[illegible]

CHAMBER  
0.00" to 2 1/4 9/16"

DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH		
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.416	+.017	4.417	+.001
31.00	187.50	23.00	4.427	.30	.430	3
30.00	188.50	22.00	4.437	.40	.440	3
29.85	188.65	21.85	4.438	+.041	4.441	+.003
26.40	192.10	18.40	4.977	-.020	4.980	+.003
26.00	192.50	18.00	4.985	.11	.989	4
24.00	194.50	16.00	5.025	+.028	5.028	3
22.00	196.50	14.00	5.065	.68	.068	3
20.00	198.50	12.00	5.105	1.08	.108	3
18.00	200.50	10.00	5.145	1.47	.147	2
16.00	202.50	8.00	5.185	1.88	.188	3
14.00	204.50	6.00	5.225	2.29	.229	4
12.00	206.50	4.00	5.265	2.70	.270	5
10.00	208.50	2.00	5.305	3.09	.309	4
9.00	209.50	1.00	5.325	3.28	.328	3
8.50	210.50	.50	5.335	3.27	.337	2
8.25	210.25	.25	5.340	3.42	.342	2
8.10	210.10	.10	5.343	+.345	5.345	+.002

SPECIAL MEASUREMENTS					
	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	218.50"	—	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	210.50"	210.50"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	8.00"	—	NUMBER OF LANDS AND GROOVES	28	28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

NOT STAMPED RODMAN	STARGAUGED AND INSPECTED BY S. McWilliams	REVIEWED BY
D. Tesch	TIME	COMPILATOR
RECORDER J. Clark	PLACE 525	GRAPHED BY

105 N/M TUBE #24850 M68 WTV. ARES. FOR: MR. MUSIC  
10446-78 AF 620 Rds. W.O. 445-36852-87



Page 3 of 3

Size	105mm Tube	Number	24850	Model	m68	Manufacturer	WTV. ARS.
Date of Gaging	10 AUG 78	Firing Status (Check one)	Before <input type="checkbox"/> After <input checked="" type="checkbox"/>	Number of Rounds	620	Proof Officer	MR. MURKICK
<p style="text-align: center;">INSPECTION REMARKS</p> <p style="text-align: center;">(PT-IOP 750-1)</p> <p>BORESKOPED: (Not chrome plated)</p> <p>Light scratches, stains, carbon and other deposits throughout chamber and main bore. Two piezo gage holes drilled in chamber. One at 14.37" from rear face of tube (RFT) in the 10:00 o'clock area and one at 20.5" from (RFT) in the 2:30 o'clock area. Light erosion and scoring encircling both holes. Two piezo gage holes drilled in bore. One at 28" from (RFT) in the 2:30 o'clock area. Moderate to light heat checking, erosion and scoring encircling piezo gage holes in bore, more pronounced on forward edge. Moderate to light heat checking encircling non-rifled portion of forcing cone and extending forward to 80" in the grooves and to 105" on the lands from (RFT). Any further heat checking obscured by carbon deposits. Moderate to light erosion and light longitudinal scoring encircling forcing cone with scoring extending forward to 35" and erosion extending forward to 70" from (RFT). Edges of lands rounded throughout eroded area with driving edge rounded as far forward as 100" from (RFT). Moderate to heavy erosion and scoring encircling bore evacuator holes, more pronounced on forward edges. Appearances of crack patterns in two grooves adjacent to the 9:00 o'clock hole. Tube contains damage to 18 lands in the 11:00 o'clock area between 153" and 201" from (RFT). Damages consist of lands being stripped and flattened. Tube contains moderate scoring and abrasive wear on lands and in the grooves between 60" from (RFT) and the muzzle. Light coppering in bore between origin of rifling and 45" from (RFT).</p> <p>No photographs or impressions taken at this time.</p> <p>Tube declared "HAZARDOUS" due to damage in bore. Stencil and handle in accordance with M.P. 750-1.</p>							



MULTIPLE STARGAGE MEASUREMENT & INSPECTION DATA FORM (PT-IOP 750-1)

105 MM Tube, M68		Main Bore - 21.91" to 210.50"				
Distance (Inches) from		Muzzle Face				
Rear Face of Bore	Muzzle Face	Rear Face of Tube	4.134" Basic Diameter Vert.	4.224" Basic Diameter Hor.	4.134" Basic Diameter Vert.	4.224" Basic Diameter Hor.
218.25	.25	210.25				
217.00	1.50	209.00				
215.00	3.50	207.00				
213.00	5.50	205.00				
208.00	10.50	200.00				
203.00	15.50	195.00				
198.00	20.50	190.00				
193.00	25.50	185.00				
188.00	30.50	180.00				
183.00	35.50	175.00				
178.00	40.50	170.00				
173.00	45.50	165.00				
168.00	50.50	160.00				
163.00	55.50	155.00				
158.00	60.50	150.00				
153.00	65.50	145.00				
148.00	70.50	140.00				
143.00	75.50	135.00				
138.00	80.50	130.00				
133.00	85.50	125.00				
128.00	90.50	120.00				
123.00	95.50	115.00				
118.00	100.50	110.00				
113.00	105.50	105.00				
108.00	110.50	100.00				
103.00	115.50	95.00				
98.00	120.50	90.00				
93.00	125.50	85.00				
88.00	130.50	80.00				
83.00	135.50	75.00				
78.00	140.50	70.00				
73.00	145.50	65.00				
68.00	150.50	60.00				
63.00	155.50	55.00				
58.00	160.50	50.00				
53.00	165.50	45.00				
48.00	170.50	40.00				
43.25	173.25	37.25				
43.00	175.50	35.00				
42.25	177.25	33.25				
38.00	180.50	30.00	+0.025	+0.030	+0.016	+0.015
37.00	181.50	29.00	34	32	16	17
36.00	182.50	28.00	31	30	16	21
35.00	183.50	27.00	28	27	13	20
34.00	184.50	26.00	25	26	13	17
33.50	185.00	25.50	24	23	13	18
33.25	185.25	25.25	40	39	17	16
33.10	185.10	25.10	+0.047	+0.046	+0.016	+0.016
Pullover Meas.		Vert.	Hor.	4.176" 4.175"		
25.25"		4.176" 4.175"				
Tube declared hazardous due to damage in bore		4.176" 4.175"				
DATE OF GAUGING 15 AUG 78		4.176" 4.175"				
105 MM Tube		4.176" 4.175"				
105 MM Gun		4.176" 4.175"				

105 MM Tube M68				CHAMBER 0.00" to 24.94"		
DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH		
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.426			
31.00	187.50	23.00	4.427			
30.00	188.50	22.00	4.437			
29.85	188.65	21.85	4.438			
26.40	192.10	18.40	4.977			
26.00	192.50	18.00	4.985			
24.00	194.50	16.00	5.025			
22.00	196.50	14.00	5.065			
20.00	198.50	12.00	5.105			
18.00	200.50	10.00	5.145			
16.00	202.50	8.00	5.185			
14.00	204.50	6.00	5.225			
12.00	206.50	4.00	5.265			
10.00	208.50	2.00	5.305			
9.00	209.50	1.00	5.325			
8.50	210.50	.50	5.335			
8.25	210.25	.25	5.340			
8.10	210.40	.10	5.343			

SPECIAL MEASUREMENTS				
	BASIC	ACTUAL		
TOTAL LENGTH OF GUN	218.50"		ROTATION OF TUBE AT BREECH	
TOTAL LENGTH OF TUBE	210.50"		MOVEMENT OF TUBE AT BREECH	
DEPTH OF BREECH RECESS	8.00"		NUMBER OF LANDS AND GROOVES	28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

Borescoped: no appreciable change in bore of tube since last borescoping dated 10 Aug 18 after firing Rds.

STAMPED		STARGAUGED AND INSPECTED BY	REVIEWED BY
RODMAN	Gilley	E. Moody	COMPILATOR
RECORDER	Clark	PLACE Barr. 13	GRAPHED BY

105 M/M TUBE  
AF

M68  
Rds.



(PT-IOP 750-1

105 MM Tube		105 MM Gun		24850		MODEL 1468		MANUFACTURER WVT. ARS.		CASTING NUMBER	
DATE OF GAUGING 17 AUG. 78		FIRING STATUS (Check One)		NUMBER OF ROUNDS 820		PROOF OFFICER MR. MUSICK W.O. 445-36852-87					
		BEFORE		AFTER							
105 MM Tube, M58						Main Body - 24.91" to 210.50"					
Distance (Inches) from						Muzzle Face					
Rear Face of Breech						Rear Face of Tube					
						Basic Diameter					
						Basic Diameter					
						Vert. Hor. Vert. Hor.					
218.25						.25 210.25					
217.00						1.50 209.00					
215.00						3.50 207.00					
213.00						5.50 205.00					
208.00						10.50 200.00					
203.00						15.50 195.00					
198.00						20.50 190.00					
193.00						25.50 185.00					
188.00						30.50 180.00					
183.00						35.50 175.00					
178.00						40.50 170.00					
173.00						45.50 165.00					
168.00						50.50 160.00					
163.00						55.50 155.00					
158.00						60.50 150.00					
153.00						65.50 145.00					
148.00						70.50 140.00					
143.00						75.50 135.00					
138.00						80.50 130.00					
133.00						85.50 125.00					
128.00						90.50 120.00					
123.00						95.50 115.00					
118.00						100.50 110.00					
113.00						105.50 105.00					
108.00						110.50 100.00					
103.00						115.50 95.00					
98.00						120.50 90.00					
93.00						125.50 85.00					
88.00						130.50 80.00					
83.00						135.50 75.00					
78.00						140.50 70.00					
73.00						145.50 65.00					
68.00						150.50 60.00					
63.00						155.50 55.00					
58.00						160.50 50.00					
53.00						165.50 45.00					
48.00						170.50 40.00					
43.25						173.25 37.25					
43.00						175.50 35.00					
42.25						177.25 33.25					
38.00						180.50 30.00					
37.00						181.50 29.00					
36.00						182.50 28.00					
35.00						183.50 27.00					
34.00						184.50 26.00					
33.50						185.00 25.50					
33.25						185.25 25.25					
33.10						185.10 25.10					
Pullover Meas.						Vert. Hor.					
25.25"						4.176" 4.175"					
75% Estimated						remaining accuracy					
life. (WPAAS)											
TUBE DECLARED "HAZARDOUS" DUE TO DAMAGE						IN BORE.					

105 MM Tube M68				CHAMBER 0.00" to 24.94"		
DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH		
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.416			
31.00	187.50	23.00	4.427			
30.00	188.50	22.00	4.437			
29.85	188.65	21.85	4.438			
26.40	192.10	18.40	4.977			
26.00	192.50	18.00	4.985			
24.00	194.50	16.00	5.025			
22.00	196.50	14.00	5.065			
20.00	198.50	12.00	5.105			
18.00	200.50	10.00	5.145			
16.00	202.50	8.00	5.185			
14.00	204.50	6.00	5.225			
12.00	206.50	4.00	5.265			
10.00	208.50	2.00	5.305			
9.00	209.50	1.00	5.325			
8.50	210.50	.50	5.335			
8.25	210.25	.25	5.340			
8.10	210.40	.10	5.343			

SPECIAL MEASUREMENTS					
	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	218.50"		ROTATION OF TUBE AT BREECH		
TOTAL LENGTH OF TUBE	210.50"		MOVEMENT OF TUBE AT BREECH		
DEPTH OF BREECH RECESS	8.00"		NUMBER OF LANDS AND GROOVES	28	

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

BORESKOPED: NO APPRECIABLE CHANGE IN BORE OF TUBE SINCE LAST INSPECTION DATED 15 AUG. 78

AFTER 720 Rds.

STAMPED	STARTED AND INSPECTED BY	REVIEWED BY
RODMAN	R. GILLEY	
RECORDER	TIME	COMPILATOR
J. McWilliams	PLACE	GRAPHED BY
J. McWilliams	BARR. B	

105 MM TUBE #24850 M68 FOR: MOSNAK  
17 AUG 78 AF B20 Rds. 445-36352-27



## MULTIPLE STARGAGE MEASUREMENT &amp; INSPECTION DATA FORM (PT-IOP 750-1)

105 MM Tube		105 MM Tube, M68		105 MM Tube, M68			
NUMBER	MODEL	MANUFACTURER	CASTING NUMBER	Main Bore - 24.91" to 210.50"			
				Distance (Inches) from			
				Rear Face of Breech	Muzzle Face	Rear Face of Tube	4.131" Basic Diameter
				Vert.	Hor.	Vert.	Hor.
218.25	.25	210.25	+ .007	+ .006	+ .030	+ .025	
217.00	1.50	209.00	5	4	24	21	
215.00	3.50	207.00	5	5	24	18	
213.00	5.50	205.00	5	5	23	18	
208.00	10.50	200.00	5	5	23	19	
203.00	15.50	195.00	5	5	22	20	
198.00	20.50	190.00	6	5	24	21	
193.00	25.50	185.00	7	5	24	21	
188.00	30.50	180.00	6	5	23	24	
183.00	35.50	175.00	6	6	23	22	
178.00	40.50	170.00	5	6	21	21	
173.00	45.50	165.00	5	7	21	21	
168.00	50.50	160.00	5	6	23	20	
163.00	55.50	155.00	5	5	23	20	
158.00	60.50	150.00	6	5	23	17	
153.00	65.50	145.00	6	4	24	18	
148.00	70.50	140.00	6	4	17	18	
143.00	75.50	135.00	6	4	17	18	
138.00	80.50	130.00	6	4	18	18	
133.00	85.50	125.00	4	4	17	15	
128.00	90.50	120.00	3	4	16	15	
123.00	95.50	115.00	3	4	15	13	
118.00	100.50	110.00	3	3	14	10	
113.00	105.50	105.00	3	3	13	10	
108.00	110.50	100.00	2	3	10	10	
103.00	115.50	95.00	2	3	9	8	
98.00	120.50	90.00	2	3	9	8	
93.00	125.50	85.00	2	3	8	8	
88.00	130.50	80.00	2	3	7	7	
83.00	135.50	75.00	3	5	7	7	
78.00	140.50	70.00	3	6	5	6	
73.00	145.50	65.00	8	7	5	5	
68.00	150.50	60.00	12	11	5	4	
63.00	155.50	55.00	17	16	5	4	
58.00	160.50	50.00	21	21	5	5	
53.00	165.50	45.00	26	28	6	5	
48.00	170.50	40.00	28	31	10	11	
43.25	173.25	37.25	30	31	16	14	
43.00	175.50	35.00	31	32	16	16	
41.25	177.25	33.25	34	33	18	17	
38.00	180.50	30.00	37	30	17	19	
37.00	181.50	29.00	39	38	17	19	
36.00	182.50	28.00	40	36	25	21	
35.00	183.50	27.00	24	22	30	25	
34.00	184.50	26.00	32	29	23	24	
33.50	185.00	25.50	38	38	20	19	
33.25	185.25	25.25	46	45	16	18	
33.10	185.10	25.10	+ .051	+ .049	+ .019	+ .017	
Pullover Meas.				Vert.	Hor.		
25.25"				4.182"	4.180"		
				Estimated remaining accuracy			
				life.			



DISTANCE (Inches) FROM						GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH					
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	ZERO		GAUGE READING	ACTUAL DIAMETER	DIFFERENCE	GAUGE READING	ACTUAL DIAMETER	DIFFERENCE
32.05	186.45	24.05	4.416	4.403		+ .017	4.417	+ .001	+ .017	4.417	+ .001
31.00	187.50	23.00	4.427			.30	.430	3	.030	.430	3
30.00	188.50	22.00	4.437			.40	.440	3	.040	.440	3
29.85	188.65	21.85	4.438			+ .041	4.441	+ .003	+ .041	4.441	+ .003
26.40	192.10	18.40	4.977			- .020	4.980	+ .003	- .020	4.980	+ .003
26.00	192.50	18.00	4.985			.011	.989	4	.011	.989	4
24.00	194.50	16.00	5.025			+ .028	5.028	3	+ .027	5.027	2
22.00	196.50	14.00	5.065	5.003		.068	.068	3	.067	.067	2
20.00	198.50	12.00	5.105			.107	.107	2	.107	.107	2
18.00	200.50	10.00	5.145			.147	.147	2	.147	.147	2
16.00	202.50	8.00	5.185			.188	.188	3	.188	.188	3
14.00	204.50	6.00	5.225			.229	.229	4	.228	.228	3
12.00	206.50	4.00	5.265			.270	.270	5	.269	.269	4
10.00	208.50	2.00	5.305			.309	.309	4	.309	.309	4
9.00	209.50	1.00	5.325			.328	.328	3	.328	.328	3
8.50	210.50	.50	5.335			.338	.338	3	.338	.338	3
8.25	210.25	.25	5.340			.343	.343	3	.343	.343	3
8.10	210.40	.10	5.343		+ .345	5.345	+ .002	+ .345	5.345	+ .002	

SPECIAL MEASUREMENTS

TOTAL LENGTH OF GUN	BASIC	ACTUAL	ROTATION OF TUBE AT BREECH	BASIC	ACTUAL
TOTAL LENGTH OF TUBE	210.50"	210.50"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	8.00"	—	NUMBER OF LANDS AND GROOVES	28	28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

STAMPED	STARGAUGED AND INSPECTED BY <i>R. Gilley</i>	REVIEWED BY
<i>J. McWilliams</i>	TIME	COMPILATOR
RECORDER <i>D. Tesch</i>	PLACE <i>Bldg. No. 525</i>	GRAPHED BY

105 M/TUBE 24850 M68 FOR-MR. MULLICK.  
21 AUGUST 1978 AF 920 Rds. W.O. 445-36852-87

Size	105mm	Number	24850	Model	m68	Manufacturer	WTU. ARS.
Date of Gaging	21 AUG 78	Firing Status (Check one)		Number of Rounds	Proof Officer M.R. MUSIC K		
		Before	After	920	W.O. 445-36852-87		
INSPECTION REMARKS							
(PT-ICP 750-1)							
BORE SCOPE: (Not chrome plated)							
<p>Light scratches, stains, carbon and other deposits throughout chamber and main bore. Two piezo gauge holes drilled in chamber. One at 14.37" from rear face of tube (RFT) in the 10:00 o'clock area and one at 20.5" from (RFT) in the 2:30 o'clock area. Light erosion and scoring encircling both holes. Two piezo gauge holes drilled in bore. One at 28" from (RFT) in the 10:00 o'clock area and one at 38" from (RFT) in the 2:30 o'clock area. Moderate to light heat checking, erosion and scoring encircling piezo gauge holes in bore, more pronounced on forward edge. Moderate to light heat checking encircling non-rifled portion of forcing cone and extending forward to 80" in the grooves and to 110" on the lands from (RFT). An further heat checking obscured by carbon deposits. Moderate to light erosion and light longitudinal scoring encircling forcing cone with scoring extending forward to 35" and erosion extending forward to 70" from (RFT). Faces of lands rounded throughout eroded area with driving edge rounded as far forward as 115" from (RFT). Moderate to heavy erosion and scoring encircling bore evacuator holes, more pronounced on forward edges. Driving cone of lands forward of 6:00 o'clock bore evacuator hole nicked and scraped between bore evacuator hole and 130" from (RFT). Appearances of crack patterns in two grooves adjacent to the 9:00 o'clock hole. Tube contains damage to 18 lands in the 11:00 o'clock area between 153" and 201" from (RFT). Damages consist of lands being stripped and flattened. Tube contains moderate scoring and abrasive wear on lands and in the grooves between 60" from (RFT) and the muzzle. Light connering in bore between origin of rifling and 45" from (RFT).</p>							
No photographs or impressions taken at this time.							
Tube declared "HAZARDOUS" due to damage in bore.							
Stencil and handle in accordance with M.P.-750-1							



STEAP-MT Form 106C, 1 Aug 75 (Replaces STEAP-MT Form 106, 7 Dec 71 which may be used)

105 MM Tube M68				CHAMBER 0.00" to 24.94"		
DISTANCE (Inches) FROM				GAUGE MEASUREMENTS INDICATED IN 1/1000 OF AN INCH		
REAR FACE OF BREECH	MUZZLE FACE	REAR FACE OF TUBE	BASIC DIAMETER	ZERO	GAUGE READING	ACTUAL DIAMETER
32.05	186.45	24.05	4.416	0.017	4.417	+0.001
31.00	187.50	23.00	4.427	30	430	3
30.00	188.50	22.00	4.437	40	440	3
29.85	188.65	21.85	4.438	+0.41	4.441	+0.003
26.40	192.10	18.40	4.977	-0.021	4.979	+0.002
26.00	192.50	18.00	4.985	11	989	4
24.00	194.50	16.00	5.025	+0.028	5.028	3
22.00	196.50	14.00	5.065	68	68	3
20.00	198.50	12.00	5.105	107	107	2
18.00	200.50	10.00	5.145	147	147	2
16.00	202.50	8.00	5.185	188	188	3
14.00	204.50	6.00	5.225	229	229	4
12.00	206.50	4.00	5.265	270	270	5
10.00	208.50	2.00	5.305	309	309	4
9.00	209.50	1.00	5.325	329	329	4
8.50	210.50	.50	5.335	338	338	3
8.25	210.25	.25	5.340	343	343	3
8.10	210.40	.10	5.343	+0.346	5.346	+0.003

SPECIAL MEASUREMENTS

	BASIC	ACTUAL		BASIC	ACTUAL
TOTAL LENGTH OF GUN	218.50"	—	ROTATION OF TUBE AT BREECH	—	—
TOTAL LENGTH OF TUBE	210.50"	210.58"	MOVEMENT OF TUBE AT BREECH	—	—
DEPTH OF BREECH RECESS	8.00"	—	NUMBER OF LANDS AND GROOVES	28	28

Inspection Remarks: Areas from 18.50" to 21.75" and 24.17 to 24.94" were not measured.

not stamped	STAMPED	STARGAUGED AND INSPECTED BY	REVIEWED BY
RODMAN	D. Teach	TIME	COMPILATOR
RECORDER	S. Clark	PLACE	GRAPHED BY

105 M/M TUBE #24850 M68 For: M.E. music  
S Dec 78 AF 1220 Rds. 120.445-36850-87



Size	105 M/M GUN TUBE	Number	24850	Model	M 68	Manufacturer	Wvt. Ars.	Proof Officer	Mr. Musick W.O. 445-36852-87	INSPECTION REMARKS					
										(PT-IOP 750-1)					
Date of Gaging	5 December 1978	Firing Status (Check one)		Number of Rounds	1220	BORESKOPED; (Not chrome plated). Light scratches, stains, carbon, and other deposits throughout chamber and main bore. Two piezo gauge holes drilled through chamber wall, one 14" from rear face of tube (RFT) in the 10:00 o'clock area and one 20.5" from (RFT) in the 2:30 o'clock area. Light erosion and scoring encircling both holes. Two piezo gauge holes drilled through tube wall, one 28" from (RFT) in the 10:00 o'clock area and one 38" from (RFT) in the 2:30 o'clock area. Moderate to light heat checking, erosion, and scoring encircling piezo gauge holes in bore, more pronounced on forward edges. Moderate to light heat checking encircling centering cylinder beginning 23.50" from rear face of tube and extending forward into main bore to 80" from (RFT) in the grooves and to 110" on the lands. Any further heat checking obscured by carbon deposits. Moderate to light erosion encircling forcing cone and extending forward to 78" from (RFT). Light longitudinal scoring on lands and in grooves between forcing cone and 35" from (RFT). Edges of lands are rounded throughout eroded area with driving edges rounded as far forward as 115" from (RFT). Moderate to heavy erosion and scoring encircling bore evacuator holes, more pronounced on forward edges. Driving edge of land forward of 6:00 o'clock bore evacuator hole nicked and scraped between bore evacuator hole and 130" from (RFT). Tube contains damage to 18 lands between 153" and 201" from (RFT). Damages consist of lands being stripped and flattened. Tube contains moderate scoring and abrasive wear on lands and in grooves between 60" from (RFT) and muzzle. Light coppering in bore between origin of rifling and 45" from (RFT).									
		After								No photographs or impressions taken at this time.					
		Before				Tube declared "HAZARDOUS" due to damage in bore. Tube declared "UNSERVICEABLE" due to rounds in excess of E.F.C. limit of 1000. Stencil and handle in accordance with M.P. 750-1.									



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